The Impacts of Armed Conflict on Child Health: Evidence from 56 Developing Countries

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Abstract: This article evaluates the extent to which armed conflicts influence early childhood health for 56 developing countries over nearly 30 years. Exploiting both spatial and temporal variations in conflict exposure within a difference-in-differences framework, we uncover detrimental ramifications of armed conflicts on the health outcomes of children under five years old. Particularly, children exposed to armed conflicts have lower height-for-age, weight-for-height, and weight-for-age z-scores by 0.08, 0.05, and 0.10 standard deviations, respectively, compared to the average corresponding z-scores of children unexposed to armed conflicts. Besides, exposure to armed conflicts make children 2.2, 0.8, and 2.6 percentage points more likely to be stunted, wasted, and underweight, respectively. Taking the proportions of stunted, wasted, and underweight children who were unexposed to armed conflicts as the benchmarks, these estimates represent the 7.3%, 7.9%, 10.2% increases in the incidences of stunting, wasting, and underweight, respectively. Our heterogeneity analyses further suggest that children born to low education mothers, children from relatively poor households, and children living in rural areas are especially vulnerable.

JEL codes: I10, I15, J13, O15

Keywords: Armed Conflicts; Child Heath; Anthropometry; Developing Countries

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1 Introduction

As the number of major armed conflicts has almost tripled in the past ten years, battlefield related deaths have seen a six-fold increase (Von Einsiedel et al., 2017; Dupuy & Rustad, 2018). In 2016, approximately 70-92% of deaths induced by armed conflicts involved civilians (United Nations, 2017). United Nations (2017) emphasize that armed conflicts lead to not only immediate civilian deaths and injuries but also the destruction of critical infrastructure and essential services. The estimated financial loss amounted to 14.3 trillion USD in 2016, which is equivalent to 12.6% of global GDP.

In this article, we investigate the extent to which armed conflicts influence the health outcomes of children for 56 developing countries in the past three decades (1990-2018). The contribution of our work to the literature is threefold. First, we analyze the less visible but critical cost of conflicts, while other studies tend to focus on individuals with urgent humanitarian needs (Bruck, Justino & Martin-Shields, 2017). Second, instead of quantifying the impacts of interest for one individual country, this article covers 56 developing countries across five continents spanning from 1990 to 2018. The wide coverage across time and space lends the external validity to our results. In other words, the temporal and spatial dimensions of this article sample make our conclusions meaningful to policymakers from many governments. Finally, we conduct heterogeneity analyses to see if the impacts of armed conflicts differ across populations of different socioeconomic backgrounds and demographic characteristics. Doing so helps us identify the most vulnerable groups that need extra attention from policymakers.

In terms of identification, we adopt the difference-in-differences (DiD) model. In particular, we exploit the variation across districts in exposure to armed conflicts and the variation within a given district in the timing of whether the child was exposed to armed conflicts due to his/her birth month-year. The data for our empirical analyses are drawn from the Demographic and Health Surveys supplemented with GPS datasets (DHS-GPS) and the Uppsala Conflict Data Program Geo-referenced Event Dataset (UCDP-GED). Detailed information on children's health outcomes (proxied by anthropometric z-scores), children' as well as mothers' characteristics are obtained from the DHS-GPS. We also rely on the UCDP-GED for a comprehensive list of armed conflicts worldwide.

The article reaches the following findings. First, we present compelling evidence on the detrimental ramifications of armed conflicts on child health. In particular, children exposed to armed conflicts have lower height-for-age, weight-for-height, and weight-for-age z-scores by 0.08, 0.05, and 0.10 standard deviations, respectively, compared to the average corresponding z-scores of children unexposed to armed conflicts. Furthermore, exposure to armed conflicts make children 2.2, 0.8, and 2.6 percentage points more likely to be stunted, wasted, and underweight, respectively. Taking the proportions of stunted, wasted, and underweight children who were unexposed to armed conflicts as the benchmarks, these estimates represent the 7.3%, 7.9%, 10.2% increases in the incidences of stunting, wasting, and underweight, respectively. Finally, our heterogeneity analyses highlight the vulnerability to armed conflicts among children from disadvantaged backgrounds. Particularly, children of low-education mothers, those from relatively poor households, and those living in rural areas tend to bear the larger health setbacks.

Our findings underscore the less visible but critical costs of armed conflicts. To the extent that poor health in early life can hamper school performance, impair cognitive and social development, as well as decrease future earnings (Martorell, 1999; Glewwe, Jacoby & King, 2001; Briend & Berkley, 2016), the adverse impacts of armed conflicts on child health could have serious implications from both individual and social perspectives. Therefore, this article implies that interventions that aim to ensure the nutrition of children are of utmost importance and should be implemented during and after conflicts. Extra attention should be given to children of disadvantaged backgrounds such as children born to low education mothers, children from poor families, and children living in rural areas as they tend to be the most vulnerable groups.

The article proceeds as follows. Section 2 discusses the related literature. Section 3 describes the data. Section 4 outlines the empirical methodology. Section 5 discusses the results. Section 6 concludes.

2 Literature review

This article is related to two strands of literature. The first strand of literature focuses on is the sensitivity of child health to extreme events where children in developing countries are highly vulnerable (Hoddinott & Kinsey, 2001; Bengtsson, 2010). It is documented that adverse economic shocks lead to worse health for children through the declines in household living standards (Maluccio, 2005; Stillman & Thomas, 2008; Page, Schaller & Simon, 2019). Famine is another adverse event that could slow child's growth and could be devastating for child survival (Biellik & Henderson, 1981; Kiros & Hogan, 2001). Besides, extreme climatic events have been shown to deteriorate child health. For instance, Skoufias & Vinha (2012), Jacoby, Rabassa & Skoufias (2014) and Le & Nguyen (2021) find that rainfall shocks make children both shorter for their age and thinner for their height. Lazzaroni & Wagner (2016) uncover the inimical effects of drought on child's weight-for-age. This article contributes to this strand of literature by focusing on armed conflict as an extreme circumstance and shedding light on how such circumstance aggravates child health.

The second line of literature this article also fits into is the cost of armed conflicts. Besides the visible costs such as the loss of lives and the destruction of production capacity (Dunne, Hoeffler & Mack, 2013), the less visible yet dreadful cost of armed conflicts lies with human capital. For example, armed conflicts are reported to both worsen the quality of learning (Bruck, Di Maio & Miaari, 2019) and shorten educational attainment (Le & Nguyen, 2020[a]). Furthermore, it is documented that armed conflicts impose detrimental effects on the health outcomes of individuals. For instance, Akbulut-Yuksel (2014) find that individuals exposed to armed conflicts had lower self-reported health satisfaction. Infant health is also highly vulnerable to the injurious consequences of armed conflict as Quintana-Domeque & Rodenas-Serrano (2017) show that prenatal exposure to armed conflicts leads to lower weight at birth. Besides, armed conflicts have been shown to reduce institutional child delivery and raise the risk of maternal death (Østby et al., 2018; Kotsadam & Østby, 2019). Moreover, there is evidence that wars in Africa could lead to the worst outcomes for children in the form of death (Macassa et al., 2003; Wagner et al., 2018) whereas official development aid in war-inflicted areas might be effective in reducing child mortality (Kotsadam et al., 2018).

Closest to our article is the studies that explore how exposure to civil war influences the health outcomes of children. Exploiting the differential timing and location of conflicts, Bundervoet, Verwimp & Akresh (2009) report a decrease of 0.047 standard deviations in height-for-age for Burundi children living in conflict regions compared to same-age children outside conflict regions. Within the contexts of Eritrea and Côte d'Ivoire, Akresh, Lucchetti & Thirumurthy (2012) and Minoiu & Shemyakina (2014) find that exposure to armed conflicts leads to the decreases of 0.42 and 0.2-0.4 standard deviations in children's height-for-age z-scores, respectively.

This article complements these works and contributes to the literature in three ways. First, instead of only looking at height-for-age z-scores, we examine three anthropometric measures proxying for child health, namely, height-for-age, weight-for-height, and weight-for-age z-scores. Besides, we further construct three corresponding indicators, stunting, wasting, and underweight to capture child's nutritional statuses. Second, we conduct a thorough heterogeneity analysis to identify the most vulnerable group to armed conflicts. Finally, instead of studying one particular country, we investigate the impacts of armed conflict on the health outcomes of children in 56 developing countries spanning from 1990 to 2018. The wide coverage across time and space lends support to the external validity of our estimates.

3 Data

Our data are primarily drawn from the Demographic and Health Survey (DHS) and the Uppsala Conflict Data Program Geo-referenced Event Dataset (UCDP-GED). The DHS provides us with detailed information, both demographic and anthropometric, on children under five years old. The UCDP-GED is a comprehensive dataset on armed conflicts worldwide since the beginning of 1989. We proceed to describe each dataset in more detail below.

3.1 Data on children

To investigate the impacts of armed conflict on child health, we utilize the data from the Demographic and Health Surveys (DHS) operated by the Inner City Fund International. The DHS Program has been implemented in overlapping five-year phases.[1] Administered in over 90 developing countries, the DHS is a rich dataset covering a wide range of topics such as population, education, health, and nutrition. We mainly rely on the DHS child file which focuses on children under five (0-59 months old) whose mothers are in reproductive ages (15-49) at the time of survey. The data offer a wide range of mother and child characteristics such as mother's education, child's gender, birth order, birth plurality, child's birth year, among others.

Child health is measured by three commonly used anthropometric z-scores including height-for-age, weight-for-height, and weight-for-age z-scores, which are calculated for children under five by their age and sex. Such child health measurements are carried out by the DHS enumerators. The z-scores reflect the number of standard deviations each measure lies below or above the median values of an international reference population, which is the National Center for Health Statistics (NCHS) growth reference adopted by the World Health Organization (i.e. NCHS/WHO international reference population). The three anthropometric z-scores capture the health statuses of children in both the short run and the long run. A low height-for-age is caused by either the prolonged lack of nutrients that support normal growth or repeated illness suffering, which reflects long-run health. A low weight-for-height is caused by recent adverse circumstances such as a significant reduction in food consumption or serious illness, which reflects short-run health. A low weight-for-age is the combination of a low height-for-age and a low weight-for-height. Besides the height-for-age, weight-for-height, and weight-for-age z-scores, we further construct three corresponding nutritional indicators. Stunting, wasting, and underweight are one-zero indicators taking the value of one if heightfor-age, weight-for-height, and weight-for-age z-scores are below -2, respectively, and zero otherwise. The threshold value of -2 is established by WHO (1997).

We utilize information from DHS surveys that have Global Positioning System (GPS) component available (DHS-GPS). The reason is that the DHS-GPS provides detailed information on the geographic locations of children. In particular, there are latitude and longitude identifiers for the residential cluster of the child's household. The lowest administrative level that the lat-long coordinates fall into is the district (administrative level 2). Using the information on household's geographic location, we can merge the child data with the data on conflict.

[1] The years included in each DHS wave are as follows. DHS-I: 1984–1990; DHS-II: 1989-1993; DHSIII: 1992-1998; DHS-IV: 1997-2003; DHS-V: 2003-2008; DHS-VI: 2008-2013; DHS-7: 2013-2018. More information on the data structure can be found at https://dhsprogram.com/data/Guide-to-DHSStatistics/Description_of_The_Demographic_and_Health_Surveys_Program.htm.

3.2 Data on conflict

Data on armed conflicts are drawn from the latest version (version 19.1) of the Uppsala Conflict Data Program Geo-referenced Event Dataset (UCDP-GED). Developed by the Department of Peace and Conflict Research of Uppsala University, the UCDP-GED records armed conflicts globally since the beginning of 1989 (Sundberg & Melander, 2013). For each event of armed conflict, UCDP-GED records the location and date of occurrence. The location of occurrence can be identified with one pair of latitude and longitude coordinates. The lowest administrative level that the coordinates fall into is the village/town (administrative level 3). The lowest level of occurrence date is the day.

To construct the estimation sample, we first need to aggregate the armed conflict events in the UCDP-GED to the district level since the smallest administrative unit DHS-GPS coordinates fall into is the district while the lowest administrative level that UCDP-GED coordinates fall into is the village/town. Once the DHS-GPS are merged with the UCDP-GED data, we can identify whether the child's district experienced any armed conflict. As we know the child's birth date and the occurrence date of conflict, we can tell if the child was exposed to armed conflicts. Our conflict exposure measure (Exposed) is an indicator that takes the value of one if there existed armed conflicts after the child was born and before the survey date, zero otherwise. For instance, let us consider a conflict that started in February 2003 and ended in December 2005 in a given district. For children who enter the survey in 2007, those born before December 2005 were exposed to the conflict (Exposed = 1) while those born in January 2006 and afterward were not affected (Exposed = 0). If the conflict lasted until 2008, then all children in the 2007 survey belong to the exposed group (Exposed = 1).

[Table I in here]

3.3 Estimation sample

Our sample consists of approximately one million children under five years old across 56 developing countries where armed conflicts occurred between 1990 and 2018. Our analysis includes countries that account for 61.51% of global conflict. Table A1 in the online appendix presents the list of countries and the survey years. Figure 1 illustrates the geographic coverage of our sample. Descriptive statistics of control and outcome variables for the full sample and disaggregated by conflict exposure status are reported in Table I. Panel A provides the control variables. Approximately 12% of children were exposed to armed conflicts. Around half of the children are male and the fraction is similar across exposed and unexposed groups. The average birth order is 3 and it is slightly smaller for the exposed children. The proportion of children who experienced armed conflicts during the in-utero period is 7.1% for the full sample. 42% of children in the exposed group were also exposed to armed conflicts during utero while the fraction is 2.4%

among the unexposed children. The mean of mother's age is 28 years old for the full sample, with the values being almost identical across the two groups. The average years of mother's education are 5 years while it is slightly larger for the unexposed group.

[Figure 1 in here]

Panel B provides the summary statistics for our outcome variables. The mean values of all anthropometric z-scores are negative, indicating that the health measures of children from our sample are below the world's median values which also include children from developed countries. The average height-for-age, weight-for-height, and weight-for-age z-scores are -1.2, -0.5, and -1.2 standard deviations. Looking at the raw means, all anthropometric z-scores are smaller for children in the exposed group. As for stunting, the proportions of stunted children are 35% and 30% for the exposed and unexposed groups. Regarding wasting, 12% of armed conflict exposed children are wasted while the fraction is only 10% for unexposed children. In terms of underweight incidence, 34% of the children who experienced armed conflicts suffer from underweight whereas only 25% of unexposed children suffer from the same problem.

4 Empirical methodology

To evaluate the effects of armed conflicts on child health, we exploit the differential timing and location of conflicts in a difference-in-differences (DiD) model given by,

$$Y_{isdct} = \beta_0 + \beta_1 Exposed_{sdct} + X'_{iscdt}\Phi + \delta_s + \lambda_d + \theta_t + \gamma_c \times t + \epsilon_{isdct} \qquad (1)$$

where the subscripts *i, s, d, c,* and *t* correspond to child, birth month-year, residential district, country, and survey year, respectively. Y_{isdct} represents child health measured by three anthropometric z-scores (height-for-age, weight-for-height, weight-for-age) and three nutritional statuses (stunting, wasting, and underweight). Our main explanatory variable, $Exposed_{sdct}$, is an indicator that takes the value of one if there existed armed conflicts after the child was born and before the survey date, zero otherwise. For example, if a conflict occurred from February 2003 to December 2005 in a given district. For children who enter the survey in 2007, those born before December 2005 are exposed to the conflict ($Exposed_{sdct} = 1$) while those born in January 2006 and afterwards are unexposed ($Exposed_{sdct} = 0$).

Vector X'_{iscdt} includes mother characteristics (age, age at birth, education) and child characteristics (gender, age, birth order, birth plurality, and whether the child was exposed to armed conflicts during the utero period). We denote by δ_s, λ_d, and θ_t child's birth month-year, residential district, and survey year fixed effects, respectively. The country-specific linear trend (at the child's birth month-year level), $\gamma_c \times t$, accounts for differential trends in child health and armed conflicts in different countries. Finally, the term ϵ_{isdct} stands for the error term. Standard errors throughout the article are clustered at the district level since our source of variation is at the district level.

The coefficient of interest is β_1 which captures the extent to which exposure to armed conflicts affects child health. Our DiD framework exploits variation across both spatial and temporal dimensions. The spatial dimension refers to the variation across districts in exposure to armed conflicts. The temporal dimension refers to the variation within a given district in the timing of whether the child was exposed to armed conflicts due to birth timing. Our identification strategy hinges upon the comparison of health measures of similarly aged children in conflict and non-conflict districts. The underlying assumption is that differences across birth cohorts (born before or after the conflict ended) in average anthropometric measures would be similar across conflict and non-conflict districts in the absence of the conflict. This assumption is likely to be valid as shown in prior studies (Bundervoet, Verwimp & Akresh, 2009; Akresh, Lucchetti & Thirumurthy, 2012; Minoiu & Shemyakina, 2014). It is also worth noting that the survey years are not the same for all countries, making the data an unbalanced panel. In this case, it is assumed that the missing of certain survey years for countries is uncorrelated with district unobserved time-variant characteristics affecting child health and conflict timing at the same time. Overall, this assumption is likely to hold because households and survey timing are computationally pre-selected in the central DHS office prior to the start of fieldwork, which should not be influenced by local conditions.

5 Results

5.1 Main results

Estimates of the effects of exposure to armed conflicts on child health are provided in Table II, III, and IV. The structure is as follows. Results for anthropometric z-scores are displayed in Columns 1 through 4 and results for corresponding nutritional statuses are reported in Columns 5 through 6. Columns 1 and 5 provide our most parsimonious specification conditioning only on the main explanatory variable. In Columns 2 and 6, we introduce a covariate of controls (mother-child characteristics). In Columns 3 and 7, we add child's birth month-year, residential district, and survey year fixed effects to the specifications in Columns 2 and 6. Columns 4 and 8 present our most extensive specifications where we control for a full set of controls, all fixed effects, and country-specific linear trend.

Height-for-age − The estimated effects of armed conflict exposure on height-for-age are presented in Table II. Starting with the most parsimonious specifications, Columns 1 and 5 suggest a negative association between armed conflict exposure and child's height-for-age. Specifically, experiencing armed conflicts is associated with a decrease in height-for-age z-score by 0.20 standard deviations and an increase in the incidence of stunting by 4.8 percentage points. However, these estimates do not adequately reflect the relationship between armed conflicts and child's height-for-age because these specifications do not account for important factors that could be corrected with armed conflicts and at the same time could affect child health. For instance, given the importance of mother's education (Alderman & Headey, 2017; Le &

Nguyen, 2020[c]), children born to highly educated mothers might be better protected from the adverse consequences of armed conflicts compared to those born to lower educated mothers. Another factor is the child's birth order as parental investment which favors the first-born child might give him/her an advantage in surviving through armed conflicts (Price, 2008). Moreover, whether the child was exposed to armed conflicts during the utero period could possibly affect his/her current health through the influence of health at birth (Le & Nguyen, 2020[b]). Therefore, we proceed to control for a variety of mother-child characteristics (mother's age, mother's age at birth, mother's education, child's gender, child's birth order, child's birth plurality, and an in-utero conflict exposure indicator). With the inclusion of these observable characteristics, our point estimates become smaller in magnitude but the statistical significance level remains unchanged (Columns 2 and 6). In particular, children exposed to armed conflicts tend to be 0.06 standard deviations shorter for their age and 1.8 percentage points more likely to be stunted.

[Table II in here]

Despite accounting for mother's and child's observable characteristics, specifications in Columns 2 and 6 do not control for unobserved factors that could be correlated with child's height-for-age and armed conflicts. For example, children living in districts with high-quality health facilities and physicians may be equipped with better resources to counteract the adverse repercussions of armed conflicts. Even when children live in the same district, being born at different times of the year means they might and might not have been exposed to armed conflicts. These issues can be addressed with the addition of a series of time and location fixed effects. As shown in Columns 3 and 7, including fixed effects do not substantially change the results in Columns 2 and 6. Exposure to armed conflicts reduces child's height-for-age by 0.07 standard deviations and raises the incidence of stunting by 2.1 percentage points. Compared to the results in the most parsimonious specifications, estimates in Columns 3 and 7 decline by 56-64%, suggesting that failing to account for important observed and unobserved factors can bias the estimated impacts of armed conflicts.

Finally, we proceed to the most extensive specifications where we include the country-specific linear trend in addition to fixed effects and mother-child controls to account for differential trends in child health and armed conflicts in different countries. Evident from Columns 4 and 8, children exposed to armed conflicts suffer from significant health setbacks in terms of lower height-for-age z-scores and higher probability of being stunted. Specifically, experiencing armed conflicts makes children 0.08 standard deviations shorter for their age and 2.2 percentage points more likely to be stunted. Taking the average height-for-age z-scores and the fraction of stunted children among the unexposed as the benchmarks, the estimates in Columns 4 and 8 represents a 6.6% decrease in height-for-age z-score and a 7.3% increase in the stunting incidence.

Weight-for-height – The estimated impacts of armed conflicts on weight-for-height are reported in Table III. According to the most parsimonious specifications, exposure to armed conflicts is associated with a

0.30 standard deviation decrease in child's weight-for-height z-score and a 2.2 percentage point increase in the incidence of wasting (Columns 1 and 5). Controlling for important mother-child characteristics makes the point estimates shrink in magnitude but leaves the statistical significance level intact (Columns 2 and 6). The decreases in magnitude suggest that important mother and child characteristics can explain around 23-37% of the association between armed conflict exposure and weight-for-height. Accounting for time and location fixed effects further reduces the magnitude of the estimates (Columns 3 and 7), with a suggestion that failure to control for the observed and unobserved factors could overstate the impacts of armed conflicts. Columns 3 and 7 shows that experiencing armed conflicts makes children 0.05 standard deviations thinner for their height and 0.7 percentage points more likely to be wasted.

[Table III in here]

Finally, with the inclusion of the country-specific linear trend, the most extensive specifications still point to the detrimental ramifications of armed conflicts on child health. Exposure to armed conflicts reduces weight-for-height z-score by 0.05 standard deviations and raises the incidence of wasting by 0.8 percentage points. Relative to the average weight-for-height z-score and the proportion of wasted children in the unexposed group, our estimates represent a decrease of 11% in weight-for-height z-score and an increase of 7.9% in the wasting incidence.

Weight-for-age − We provide the estimates for the impacts of armed conflicts on child's weight-for-age in Table IV. Starting with the most parsimonious specifications, Columns 1 and 5 suggest that armed conflicts are negatively associated with weight-for-age z-score and positively associated with the incidence of underweight. Particularly, children experiencing armed conflicts tend to be 0.3 standard deviations thinner for their age, and 8.7 percentage points more likely to be underweight. Controlling for important mother-child characteristics leaves the results qualitatively unchanged although the point estimates shrink by 45% and 40% for weight-for-age z-score and underweight incidence, respectively. Accounting for unobserved factors influencing child health through child's birth month-year, residential district, and survey year fixed effects further decreases the magnitude of the estimates. Specifically, exposure to armed conflicts leads to a 0.08 standard deviation decrease in weight-for-age z-score and a 2.6 percentage point increase in the probability of being underweight (Columns 3 and 7).

[Table IV in here]

Finally, in the most extensive specifications where we include a full set of controls, time and location fixed effects, and country-specific linear trend, we still detect negative effects of armed conflicts on child health. In particular, children exposed to armed conflicts experience serious health setbacks in terms of 0.1 standard deviations lower weight-for-age z-scores, corresponding to a 9% decline compared to children unexposed to armed conflicts. Being exposed to armed conflicts also makes children 2.6 percentage points more likely to be underweight. Taking the fraction of underweight children in the unexposed group as the benchmark, our estimate represents a 10.2% increase in the incidence of underweight.

5.2 Discussion

Collectively, we have found that children who were exposed to armed conflicts suffered substantial health setbacks compared to unexposed children. Specifically, children experiencing armed conflicts have 0.08 standard deviations lower height-for-age z-score, representing a 6.6% reduction compared to the average height-for-age z-scores of children unexposed to armed conflicts. Exposure to armed conflicts also makes children 0.05 and 0.1 standard deviations thinner for their height and thinner for their age, corresponding to the declines of 11% and 9% relative to the average weight-for-height and weight-for-age z-scores of unexposed children, respectively. Furthermore, armed conflicts raise the incidences of stunting, wasting, and underweight by 2.2, 0.8, and 2.6 percentage points, respectively. Taking the fractions of stunted, wasted, and underweight children in the unexposed group as the benchmarks, these estimates represent the increases of 7.3%, 7.9%, and 10.2% in the incidences of stunting, wasting, and underweight, respectively.

Our findings are consistent with prior literature on the cost of armed conflicts to child health. Particularly, Bundervoet, Verwimp & Akresh (2009) find that exposure to civil war reduces Burundi children's height for age z-scores by 0.047 standard deviations compared to nonexposed children. In the context of Eritrea, Akresh, Lucchetti & Thirumurthy (2012) detect a 0.42 standard deviation decline in height-for-age z-scores among war-inflicted children. Minoiu & Shemyakina (2014) show that Ivorian children exposed to armed conflicts tend to be 0.2-0.4 standard deviations shorter for their age. While our results also point to the negative effects of armed conflicts, our estimate for the effects on height-for-age z-score is smaller in magnitude than those documented in prior studies. By showing the how vulnerable child health is to armed conflicts, this article also complements the literature on the susceptibility of children to extreme events such as famine and climatic shocks (Kiros & Hogan, 2001; Skoufias & Vinha, 2012; Jacoby, Rabassa & Skoufias, 2014; Lazzaroni & Wagner, 2016; Le & Nguyen, 2021).

There are potentially four main pathways to the adverse consequences of armed conflicts. First, armed conflicts could reduce household incomes by destroying productive assets and properties as well as job opportunities (Sachs, 2008; Dunne, Hoeffler & Mack, 2013). Second, the destruction caused by conflicts might also lead to food shortage through the demolition of crops or the obstruction of international food aid (Nunn & Qian, 2014). The nutrition deficit caused by both household income losses and food shortage will ultimately aggravate child health. Third, it is possible that violence-induced displacement will disrupt everyday life, making children vulnerable to water and vector-borne diseases (Bundervoet, Verwimp & Akresh, 2009). As a result, their health outcomes are likely to be compromised. Finally, children from households where adult members suffered from conflict-induced physical or mental illnesses could receive insufficient care, making their health negatively affected.

Our findings underline the less apparent but serious cost of armed conflicts. Specifically, armed conflicts deteriorate early human capital formation in the form of worse health outcomes for young children. Given the vestigial effects of poor health in early life such as lower educational attainment, impaired cognitive ability, and declining labor productivity in the long run (Case, Fertig & Paxson, 2005; Glewwe & Miguel, 2008; Briend & Berkley, 2016), the cost of armed conflicts is far more dreadful than previously estimated. Therefore, interventions that aim to ensure the nutrition of children are of utmost importance and should be implemented during and after conflicts. Besides, reconstruction initiatives targeting conflict inflicted regions such as rehabilitating basic social services, rebuilding infrastructures, and household assets, as well as assisting the return of the displaced are also essential to restoring child health.

5.3 Heterogeneity analyses

We proceed to analyze the heterogeneous impacts of armed conflicts in various dimensions, namely, mother's education, household wealth, place of residence, and child gender. The results come from our most extensive specification and are provided in Table V. The panels indicate dimensions of heterogeneity. For each panel, each column represents a separate regression and the column headings indicate the outcome variables.

First, we present the heterogeneous impacts of armed conflicts along the lines of mother's education in Panels A and B. Panel A reports the results for children born to low education mothers (defined as those not completing primary education). Panel B presents the results for children born to high education mothers (defined as those finishing at least primary education). We find suggestive evidence that children born to low education mothers tend to be more vulnerable to armed conflicts compared to those born to high education mothers. It is possible that maternal education could help cushion the damaging consequences of adverse shocks such as armed conflicts.

[Table V in here]

Next, we explore whether the impacts of armed conflicts differ by the relative measure of household wealth. Panel C displays the results for children from relatively poor households (defined as households belonging to the bottom and second quintiles of the wealth index distribution within country and within survey wave). Panel D provides the results for children from relatively non-poor households (defined as households belonging to the second, fourth, and fifth quintiles of the wealth index distribution within country and within survey wave). The results suggest that the health setbacks induced by armed conflicts could be larger among children from relatively poor households than those from relatively non-poor households. It is possible that a more advantaged socioeconomic background might counteract the injurious repercussion of an extreme event such as armed conflict.

We proceed to examine the heterogeneous impacts of armed conflicts by place of residence in Panels E and F. We find suggestive evidence that rural children seem to be more vulnerable to the adverse ramifications of armed conflicts although both urban and rural children suffer serious health setbacks. Finally, we explore the potential gender bias in the impacts of armed conflicts. It is documented that the welfare of girls could incommensurately be compromised as resources tend to be reallocated to boys during such extreme circumstances (Duflo, 2012). As shown in Panels G and H, it seems that exposure to armed conflicts is damaging to the health outcomes of both boys and girls. We do not have enough evidence supporting gender bias.

5.4 Robustness checks

To examine the integrity of the main results presented in Section 5.1, we conduct a series of robustness checks in this section. Specifically, we test if our results are sensitive to various model specifications. The results of these exercises are reported in Table VI. In each panel, each column represents a separate regression where the estimate comes from our most extensive specification. The panel names show the types of robustness exercises. The column headings indicate the outcome variables.

Recall that in the main DiD model, our identification strategy hinges upon the comparison of health measures of similarly aged children in conflict and non-conflict districts. In the first robustness check, we implement the mother fixed-effects model where identification comes from the comparison of health measures of children born to the same mother with one child being exposed to armed conflicts and the other being unexposed. The advantage of this approach is that the within-mother comparison can account for unobserved differences in family background which could affect children's vulnerability to conflicts. The downside lies with the 54% drop in sample size because mothers with only one under five child are omitted from the sample, which could potentially bias our estimates. As shown in Panel A, we still find that exposure to armed conflicts has negative and significant impacts on child health although the estimates are larger in magnitude than those from the main DiD specification.

[Table VI in here]

We proceed to account for survey sampling weights in our main regressions in Panel B. We carefully note that the use of sampling weights in regressions might not be desirable because weighting can lower efficiency and statistical power (Winship & Radbill, 1994; Gelman, 2007; Solon, Haider & Wooldridge, 2015). In any case, with the inclusion of sampling weights, we still find adverse consequences of armed conflicts on early childhood health, as all estimates are statistically distinct from zero and close in magnitude to those in the main results (Columns 4 and 8 in Tables II through IV).

Since mothers and children might be forced to move to different areas during armed conflicts, the lack of migration information in the data might make our assignment of children to the exposed and unexposed groups (Section 3.2) inaccurate. For instance, a mother and her child could have migrated to the new district to avoid armed conflicts. According to our classification, a child is considered exposed to armed conflicts if armed conflicts occurred in the child's residential district after he/she was born and before the survey date. Therefore, in this case, being surveyed in the new district without armed conflicts, the child is categorized as unexposed. However, he/she may actually have been exposed to armed conflicts in the former residential place (the data do not allow us to know this information). To examine whether displacement could possibly influence our results, we restrict our sample to children of mothers who have resided in the same location since birth. Evident from Panel C of Table VI, the estimates are virtually unchanged in both statistical and economic terms compared to the main results (Columns 4 and 8 in Tables II through IV). These results suggest that displacement is unlikely to drive our main results.

Next, recall that in our main analysis, conflict exposure is determined at the district level. Specifically, we consider the child exposed to armed conflicts if armed conflicts occurred in the child's residential district after he/she was born and before the survey date. In the next robustness check, we determine conflict exposure at the village level instead of the district level. However, there could be two problems with this approach. First, despite the complete information on district boundary, village boundary information is missing for a number of places in the data. It is possible that villages with missing boundary information tend to be poorer as they may not have the resources to provide their geographic information at a more granular level. If such poorer villages tend to suffer more from armed conflicts, then our estimated impacts of armed conflicts on child health would be biased. Second, the missing boundary information on a number of villages results in a considerable loss of observations in our estimation (31%). In any case, we add the analysis at the village level in Panel D of Table VI. All estimates are statistically significant and close in magnitude compared to the main results.[2]

5.5 Limitations

There are three main limitations in this article. First, although our sample covers 56 developing countries, the data do not have information on several important conflict countries (e.g. El Salvador, Syria, Yemen, Iraq, Afghanistan, etc.). Since some important conflict countries are not covered, our sample may not be

[2] Besides, we also conduct the analysis at the regional level and include countries without GPS information (Congo, Brazil, Comoros, Kazakhstan, Nicaragua, Sao Tome and Principe, Turkey, and Uzbekistan). The estimates are close in magnitude and statistical significance level with our main results.

representative of the average conflict situation in the world. Moreover, if such countries were included, children from those high conflict countries might have serious health setbacks, further emphasizing our estimated impacts of armed conflicts on child health. In other words, the missing of those important conflict countries could lead to attenuation bias in our estimates.

The second limitation lies with potential mortality bias. Particularly, it is possible that armed conflicts might increase the mortality risk for young children (Wagner et al., 2018). Therefore, our sample consists of children who survive the armed conflicts to the survey. Nevertheless, the data do not allow us to account for the children who died from armed conflicts, thus they are omitted from our sample. If such children were to survive, being severely affected by conflicts could substantially devastate their health. The inclusion of those unhealthy children will further compound our estimated impacts of armed conflicts. In other words, the potential mortality bias may make our estimates the lower bounds of the true impacts of armed conflicts on child health.

The third limitation of this article is that the data do not allow us to account for the potential fertility bias. Specifically, it is possible that conflicts might have reduced fertility (Vandenbroucke, 2014; Kraehnert et al., 2019). Moreover, children who would have been born during conflicts might have had poorer health, further emphasizing our results. In other words, the omission of such (unborn) children could bias our estimates toward zero.

6 Conclusions

This article contributes to the literature by investigating the impacts of armed conflicts on the health outcomes of children in 56 developing countries from 1990 to 2018. To do so, we employ the difference-in-differences (DiD) model which is based on the comparison of health measures of similarly aged children in conflict and non-conflict districts. The data for child outcomes are drawn from the Demographic and Health Surveys supplemented with GPS datasets (DHS-GPS). We rely on the Uppsala Conflict Data Program Geo-referenced Event Dataset (UCDP-GED) for a comprehensive list of armed conflicts worldwide.

We uncover adverse consequences of armed conflicts on child health proxied by anthropometric measures. Specifically, exposure to armed conflicts reduces child's height-for-age, weight-forheight, and weight-for-age z-scores by 0.08, 0.05, and 0.10 standard deviations, respectively. Children exposed to armed conflicts are also 2.2, 0.8, and 2.6 percentage points more likely to be stunted, wasted, and underweight, respectively. Taking the fraction of stunted, wasted, and underweight children in the unexposed group as the benchmark, these estimates represent the increases of 7.3%, 7.9%, and 10.2% in the incidences of stunting, wasting, and underweight, respectively.

We further explore the heterogeneous impacts of armed conflicts along the lines of mother's education, household wealth, place of residence, and child gender. We find that children born to low education mothers, children from relatively poor families, and children living in rural areas tend to be hit harder during armed conflicts. Particularly, in terms of mother's education, exposure to armed conflicts lowers the height-for-age, weight-for-height, and weight-for-age z-scores of children born to low education mothers by 0.11, 0.05, and 0.11 standard deviations, respectively, although the impacts on children born to high education mothers are up to 49% smaller in magnitude. Regarding household wealth, exposure to armed conflicts decreases height-for-age, weight-for-height, and weight-for-age z-scores respectively by 0.13, 0.05, and 0.13 standard deviations for children from relatively poor households, whereas the corresponding impacts are 69%, 60%, and 62% smaller in magnitude for children from relatively nonpoor households. As for place of residence, while exposure to armed conflicts makes rural children 0.10, 0.06, and 0.11 standard deviations shorter for their age, thinner for their height, and thinner for their age, respectively, the corresponding impacts on urban children are 20%, 33%, and 18% smaller in magnitude. Finally, we do not have enough evidence for the gender bias as children of both sexes are almost equally affected by armed conflicts.

Collectively, this article highlights the detrimental ramifications of armed conflicts on early human health. Given the long-lasting impacts of poor health in early childhood on adult outcomes, the cost of armed conflicts is far more dreadful than previously estimated. Therefore, programs that aim to ensure the nutrition for children are important. Extra attention should be given to children of disadvantaged backgrounds such as children born to low education mothers, children from relatively poor households, and children living in rural areas as they tend to be the most vulnerable groups.

TABLES AND FIGURES

Table I. Summary statistics

	All			Exposed			Unexposed		
	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Control variables									
Exposed	0.119	0.324	1,011,611						
Gender	0.509	0.500	1,011,611	0.506	0.500	120,198	0.509	0.500	891,413
Child's Age	1.937	1.409	1,009,399	2.455	1.287	120,016	1.867	1.410	889,383
Birth order	3.149	2.236	1,011,611	3.001	2.132	120,198	3.169	2.249	891,413
Plural birth	0.012	0.108	1,011,611	0.010	0.097	120,198	0.012	0.109	891,413
In-utero exposure	0.071	0.257	1,011,611	0.419	0.493	120,198	0.024	0.154	891,413
Mother's age	28.48	6.493	1,011,611	28.62	6.238	120,198	28.46	6.526	891,413
Mother's age at birth	26.54	6.349	1,009,399	26.16	6.127	120,016	26.59	6.377	889,383
Mother's education	5.086	5.056	1,010,752	4.615	4.956	120,128	5.150	5.065	890,624
Panel B: Outcome variables									
Height-for-age z-score	-1.243	1.601	963,029	-1.417	1.562	117,215	-1.219	1.605	845,814
Weight-for-height z-score	-0.479	1.298	963,029	-0.738	1.188	117,215	-0.443	1.308	845,814
Weight-for-age z-score	-1.155	1.325	963,029	-1.450	1.233	117,215	-1.115	1.332	845,814
Stunting	0.303	0.459	963,029	0.345	0.475	117,215	0.297	0.457	845,814
Wasting	0.103	0.305	963,029	0.122	0.328	117,215	0.101	0.301	845,814
Underweight	0.265	0.441	963,029	0.341	0.474	117,215	0.254	0.436	845,814

Table II. Impacts of exposure to armed conflict on height-for-age

	Y = Height-for-age z-score				Y = Stunting			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposed	-0.198**	-0.058**	-0.070**	-0.083**	0.048**	0.018**	0.021**	0.022**
	(0.027)	(0.021)	(0.017)	(0.016)	(0.007)	(0.006)	(0.004)	(0.004)
Observations	963,029	962,737	962,714	962,714	963,029	962,737	962,714	962,714
Time trend	.	.	.	X	.	.	.	X
Fixed effects	.	.	X	X	.	.	X	X
Controls	.	X	X	X	.	X	X	X

†p<0.1, *p<0.05, **p<0.01. Each column represents the coefficient in a separate regression. Dependent variables are the child's height-for-age z-scores (Columns 1-4) and the stunting indicator (Columns 5-8). Time trend refers to the country-specific linear trend. Controls include mother's characteristics (age, age at birth, education) and child's characteristics (gender, age, birth order, birth plurality, and an in-utero conflict exposure indicator). Fixed effects include child's birth month-year, residential district, and survey year fixed effects. Robust standard errors are clustered at the district level.

Table III. Impacts of exposure to armed conflict on weight-for-height

	Y = Weight-for-height z-score				Y = Wasting			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposed	-0.295**	-0.194**	-0.046**	-0.049**	0.022**	0.017**	0.007**	0.008**
	(0.023)	(0.020)	(0.012)	(0.012)	(0.004)	(0.003)	(0.003)	(0.003)
Observations	963,029	962,737	962,714	962,714	963,029	962,737	962,714	962,714
Time trend	.	.	.	X	.	.	.	X
Fixed effects	.	.	X	X	.	.	X	X
Controls	.	X	X	X	.	X	X	X

†p<0.1, *p<0.05, **p<0.01. Each column represents the coefficient in a separate regression. Dependent variables are the child's weight-for-height z-scores (Columns 1-4) and the wasting indicator (Columns 5-8). Time trend refers to the country-specific linear trend. Controls include mother's characteristics (age, age at birth, education) and child's characteristics (gender, age, birth order, birth plurality, and an in-utero conflict exposure indicator). Fixed effects include child's birth month-year, residential district, and survey year fixed effects. Robust standard errors are clustered at the district level.

Table IV. Impacts of exposure to armed conflict on weight-for-age

	Y = Weight-for-age z-score				Y = Underweight			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposed	-0.336**	-0.184**	-0.083**	-0.095**	0.087**	0.052**	0.026**	0.026**
	(0.028)	(0.022)	(0.013)	(0.013)	(0.009)	(0.007)	(0.004)	(0.004)
Observations	963,029	962,737	962,714	962,714	963,029	962,737	962,714	962,714
Time trend	.	.	.	X	.	.	.	X
Fixed effects	.	.	X	X	.	.	X	X
Controls	.	X	X	X	.	X	X	X

†p<0.1, *p<0.05, **p<0.01. Each column represents the coefficient in a separate regression. Dependent variables are the child's weight-for-age z-scores (Columns 1-4) and the underweight indicator (Columns 5-8). Time trend refers to the country-specific linear trend. Controls include mother's characteristics (age, age at birth, education) and child's characteristics (gender, age, birth order, birth plurality, and an in-utero conflict exposure indicator). Fixed effects include child's birth month-year, residential district, and survey year fixed effects. Robust standard errors are clustered at the district level.

Table V. Heterogeneity analyses

	HAZ	WHZ	WAZ	HAZ	WHZ	WAZ
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Children of low education mothers						
Exposed	-0.105**	-0.051**	-0.107**	0.028**	0.010**	0.031**
	(0.019)	(0.015)	(0.017)	(0.005)	(0.003)	(0.005)
Observations	517,669	517,669	517,669	517,669	517,669	517,669
Panel B: Children of high education mothers						
Exposed	-0.054**	-0.043**	-0.078**	0.011*	0.005	0.017**
	(0.019)	(0.016)	(0.016)	(0.005)	(0.003)	(0.005)
Observations	440,231	440,231	440,231	440,231	440,231	440,231
Panel C: Children from relatively poor households						
Exposed	-0.134**	-0.047**	-0.127**	0.036**	0.011*	0.036**
	(0.024)	(0.018)	(0.019)	(0.007)	(0.004)	(0.006)
Observations	381,097	381,097	381,097	381,097	381,097	381,097
Panel D: Children from relatively non-poor households						
Exposed	-0.037†	-0.024	-0.054**	0.006	0.003	0.012*
	(0.021)	(0.017)	(0.019)	(0.005)	(0.003)	(0.006)
Observations	415,593	415,593	415,593	415,593	415,593	415,593
Panel E: Children from rural area						
Exposed	-0.100**	-0.059**	-0.110**	0.029**	0.010**	0.031**
	(0.019)	(0.014)	(0.016)	(0.005)	(0.003)	(0.005)
Observations	671,526	671,526	671,526	671,526	671,526	671,526
Panel F: Children from urban area						
Exposed	-0.084**	-0.037†	-0.089**	0.014*	0.002	0.021**
	(0.024)	(0.020)	(0.019)	(0.006)	(0.004)	(0.006)
Observations	291,211	291,211	291,211	291,211	291,211	291,211
Panel G: Young girls						
Exposed	-0.080**	-0.057**	-0.103**	0.022**	0.011**	0.028**
	(0.018)	(0.013)	(0.015)	(0.005)	(0.003)	(0.005)
Observations	472,556	472,556	472,556	472,556	472,556	472,556
Panel H: Young boys						
Exposed	-0.087**	-0.042**	-0.086**	0.021**	0.004	0.023**
	(0.017)	(0.014)	(0.014)	(0.004)	(0.003)	(0.005)
Observations	490,181	490,181	490,181	490,181	490,181	490,181

†p<0.1, *p<0.05, **p<0.01. The sample is split along the dimension of heterogeneity that is indicated by the panel name. For each panel, each column represents the coefficient in a separate regression. Column headings indicate dependent variables. All regressions control for mother's characteristics (age, age at birth, education), child's characteristics (gender, age, birth order, birth plurality, an in-utero conflict exposure indicator), child's birth month-year, residential district, survey year fixed effects, and country-specific linear trend. Robust standard errors are clustered at the district level.

Table VI. Robustness tests

	HAZ	WHZ	WAZ	Stunting	Wasting	Underweight
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mother fixed effects specifications						
Exposed	-0.118**	-0.057**	-0.138**	0.026**	0.004	0.029**
	(0.027)	(0.019)	(0.024)	(0.008)	(0.004)	(0.008)
Observations	447,089	447,089	447,089	447,089	447,089	447,089
Panel B: Weighted regressions						
Exposed	-0.091**	-0.038**	-0.087**	0.022**	0.007*	0.027**
	(0.017)	(0.014)	(0.014)	(0.005)	(0.003)	(0.005)
Observations	962,009	962,009	962,009	962,009	962,009	962,009
Panel C: Sample restrictions on residence time						
Exposed	-0.082**	-0.049**	-0.096**	0.020**	0.007*	0.024**
	(0.020)	(0.016)	(0.018)	(0.005)	(0.003)	(0.005)
Observations	658,587	658,587	658,587	658,587	658,587	658,587
Panel D: Armed conflicts at the village level						
Exposed	-0.057**	-0.052**	-0.082**	0.013*	0.009**	0.022**
	(0.020)	(0.013)	(0.016)	(0.006)	(0.003)	(0.005)
Observations	666,482	666,482	666,482	666,482	666,482	666,482

†p<0.1, *p<0.05, **p<0.01. In each panel, each column represents the coefficient in a separate regression. Column headings indicate dependent variables. All regressions control for mother's characteristics (age, age at birth, education), child's characteristics (gender, age, birth order, birth plurality, an in-utero conflict exposure indicator), child's birth month-year, residential district, survey year fixed effects, and country-specific linear trend. Robust standard errors are clustered at the district level.

Figure 1. Geographic coverage

The shaded regions illustrate the geographic coverage of our sample.

APPENDIX A

Table A1. List of countries

#	Code	Name[survey year]	#	Code	Name[survey year]
1	AL	Albania[08;09;17;18]	29	LB	Liberia[11;13]
2	AM	Armenia[15;16]	30	LS	Lesotho[04;09;14]
3	AO	Angola[15;16]	31	MA	Morocco[03;04]
4	BD	Bangladesh[99;00;04;07;11;14]	32	MB	Moldova[97;08;09]
5	BF	Burkina Faso[92;93;98;99;03;10]	33	MD	Madagascar[08;09]
6	BJ	Benin[96;01;11;12;17;18]	34	ML	Mali[95;96;01;06;12;13;15;18]
7	BO	Bolivia[08]	35	MM	Myanmar[15;16]
8	BU	Burundi[10;11;12;13;16;17]	36	MW	Malawi[00;04;05;10;12;14;15;16;17]
9	CD	Congo Dem Rep[07;13;14]	37	MZ	Mozambique[11]
10	CF	Central African Rep[94;95]	38	NG	Nigeria[90;03;08;10;13]
11	CI	Cote d'Ivoire[94;98;99;11;12]	39	NI	Niger[92;98]
12	CM	Cameroon[04;11]	40	NM	Namibia[00;06;07;13]
13	CO	Colombia[09;10]	41	NP	Nepal[01;06;11;16]
14	DR	Dominican Rep[04;13]	42	PE	Peru[00;05;07;08;09]
15	EG	Egypt[92;93;95;96;00;03;05;08;14]	43	PK	Pakistan[17;18]
16	ET	Ethiopia[00;11;16]	44	RW	Rwanda[05;07;08;10;11;13;14;15;17]
17	GA	Gabon[12]	45	SL	Sierra Leone[08;13]
18	GH	Ghana[93;94;98;99;03;08;14;16]	46	SN	Senegal[92;93;05;10;11;12;13;15]
19	GN	Guinea[99;05;12;18]	47	SZ	Swaziland[06;07]
20	GU	Guatemala[14;15]	48	TD	Chad[14;15]
21	GY	Guyana[05;09]	49	TG	Togo[98;13;14]
22	HN	Honduras[11;12]	50	TJ	Tajikistan[12;17]
23	HT	Haiti[00;05;06;12;16;17]	51	TL	Timor-Leste[09;10;16]
24	IA	India[15;16]	52	TZ	Tanzania[99;07;08;09;10;11;12;15;16;17]
25	JO	Jordan[02;07;12;17;18]	53	UG	Uganda[00;01;06;09;10;11;14;15;16]
26	KE	Kenya[03;08;09;14;15]	54	ZA	South Africa[16]
27	KH	Cambodia[00;05;06;10;11;14]	55	ZM	Zambia[07;13;14]
28	KY	Kyrgyz Rep[12]	56	ZW	Zimbabwe[99;05;06;10;11;15]

This table provides the list of countries in our sample. These 56 countries all experienced armed conflict between 1990 and 2018. Country code is taken from the DHS two-letter code. The superscript of country name refers to survey years. For example, [98;00;01;15] mean that the survey took place in 1998, 2000, 2001, and 2015.

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